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ABSTRACT

This study related high-inference teacher behaviors to measures of pupil achievement and attitude in ninth-grade algebra classes. A sample of 50 classes came from 13 suburban high schools. The most consistent results showed that pupil and observer assessments of clarity, enthusiasm, and task orientation were important for attitudes toward mathematics. Teachers whose pupils rated them as emphasizing analysis had classes with lower attitudes on several scales. Achievement criteria were not as productive. Nevertheless, teachers rated as higher on task orientation had higher residuals on computation and comprehensive cognitive functioning levels. Teachers rated clearer had higher residuals on comprehension. Analysis correlated with teacher behaviors of probing and enthusiasm. (Author/RH)

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RELATIONSHIPS BETWEEN SELECTED TEACHER BEHAVIORS AND ATTITUDES/ACHIEVEMENTS OF ALGEBRA CLASSES

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Paper Presented at the
Annual Meeting of the American Educational Research Association
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ABSTRACT

This study relates high-inference teacher behaviors to measures of pupil achievement and attitude in ninth grade algebra classes. The sample of fifty classes came from thirteen suburban high schools. Pupil achievement and attitudes were measured with scales from the National Longitudinal Study of Mathematical Abilities in the fall and spring of 1971-72. The posttest criterion measures were collapsed into three levels of cognitive functioning: Analysis; Comprehension; Computation. Students rated their teachers on level of cognitive processes used in the classroom and on a questionnaire designed around the Rosenshine-Furst review (1971) of process-product studies. An observer used Teacher Characteristic Study scales on four visits to the classrooms. A rating sheet designed after the Rosenshine-Furst categories was used on the last two visits. Complete data was obtained on 43 classes.

Class means formed the unit of analysis. Posttest criteria were regressed against pretest aptitude, achievement, and attitude. Residuals were correlated with teacher behavior measures.

The most consistent results showed that pupil and observer assessments of clarity, enthusiasm, and task orientation were important for attitudes towards mathematics. Teachers whose pupils rated them as emphasizing analysis had classes with lower attitudes on several scales.

Achievement criteria were not as productive. Nevertheless, teachers rated as higher on task orientation had higher residuals on Computation and Comprehension. Teachers rated clearer had

higher residuals on Comprehension. Analysis correlated with Probing and Enthusiasm. Teachers who talked more had higher Analysis residuals.

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RELATIONSHIPS BETWEEN SELECTED TEACHER BEHAVIORS AND ATTITUDES/ACHIEVEMENTS OF ALGEBRA CLASSES

J. W. McConnell

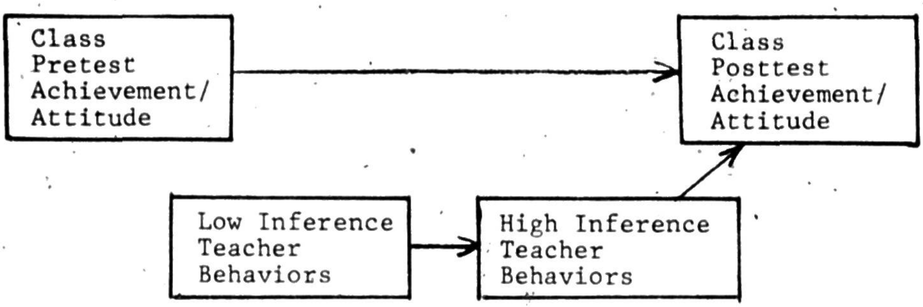
THE PROBLEM

The purpose of this study was to relate teacher behavior measures to pupil achievement and attitude measures in ninth grade algebra classes. Algebra classes were selected for the study for several reasons. First, the content of algebra is highly structured and contributes to teacher-pupil interaction. Second, the content is fairly standard across classes throughout the United States even though this country does not have a national curriculum. Third, the researcher's work in mathematics classrooms had convinced him that algebra is the key to later work in mathematics. A successful experience in algebra promotes enrollment in later mathematics courses. If teacher behaviors important for pupil achievement and positive attitude can be identified, then these behaviors can be encouraged in the classroom to improve retention of students in secondary school mathematics programs.

This study used both high and low inference measures of teacher behavior. The model for relating the teacher behaviors to outcome measures in this study are shown in Figure 1.

Figure 1

Relationships of Variables in This Study



The chief influence on end of year achievement and attitude was hypothesized to be initial achievement and attitude. Once this major influence of initial standing on measures was accounted for, the influence of teacher behavior could be considered. These were conceptualized in two stages: the high-inference measures as affecting the class achievement and attitude, and the low-inference measures as determining the high-inference measures. This paper will focus on the relationships of the high-inference measures on class achievement and attitude.

Teacher behavior measures were selected with two considerations. First, they should reflect social climate of the classroom, and they should reflect the structure of the course content. Second, they should utilize an outside observer and "inside" observers (the pupils).

Two works will be frequently referred to in this paper. The National Longitudinal Study of Mathematical Abilities (NLSMA) of the School Mathematics Study Group (SMSG) was a national project to evaluate changes in student mathematics behaviors during 1962 to 1967. Three populations were followed during this time: X-population (from Grade 4); Y-population (from grade 7); and Z-population (from grade 10). Over 112,000 students in 1,500 schools in 40 states participated in the study. Scales for measurements of arithmetic

skills, algebraic skills, and attitude towards mathematics were carefully developed and tested by teams of mathematicians, mathematics educators, statisticians, and psychologists. By producing these scales, NLSMA was a major contributor to progress in research on mathematics education.

The second work is the Rosenshine and Furst's review of process-product studies, "Research on Teacher Performance Criteria." (1971) This review organized the results of fifty correlational studies into high-inference variables which were supported in several of the studies. Five of the variables which were most conclusive were Clarity, Variability, Enthusiasm, Task-Oriented and/or Businesslike Behaviors, and Student Opportunity to Learn Criterion Material. Six which were less conclusive were Indirectness, Criticism, Structuring, Types of Questions, Probing, and Difficulty of Instruction. The influence of these variables on this study will be seen in the scales used to observe pupil behavior.

DESIGN

MEASURES OF PUPIL APTITUDE, ACHIEVEMENT AND ATTITUDE

Aptitude

Achievement in algebra is dependent upon ability. Even though the schools in this study have had procedures to select students for a homogeneous grouping in algebra, the ability levels within the classes spanned a wide range and contributed to variability in student performance at the end of the course. Further, in this study, it was clear that the schools involved had different selection procedures for algebra. These differences alone would lead to class differences in achievement at the end of the year.

A measure of students' initial abilities was chosen to account for these differences. The Short Test of Educational Ability, Level 5 (SRA, 1969) was selected because it could be administered in 30 minutes and provided scores in four areas: Verbal Meaning, Arithmetic Reasoning, Letter Series, and Symbol Manipulation. The total score on the 55 items averaged 33.39 over the students who were in both the fall and spring testings. This is roughly equivalent to an IQ of 116. Since class means were used for the analysis of data in this study, separate scores on the four subscales were used for the analysis. Means and standard deviations are reported in Table 1.

TABLE I

MEANS, STANDARD DEVIATIONS, AND RELIABILITIES FOR ~~47~~ 50 CLASSES ON SCALES FROM THE PRETESTING WITH THE SHORT TEST OF EDUCATIONAL ABILITY (STEA) LEVEL 5 (n=50 classes)

	Items	MEAN	SD	r_1	r_2
Verbal Meaning	15	9.14	1.02	.73	.87
Arithmetic Reasoning	10	6.41	.65	.69	.75
Letter Series	15	10.56	.94	.85	.88
Symbol Manipulation	15	8.18	.99	.78	.89
TOTAL	55	33.39	2.61	.89	.93

r_1 -- Hoyt reliability over students

r_2 -- Hoyt reliability over classes

Achievement

Both the fall testing and the spring testing included tests which measured achievement in mathematics. The fall testing concentrated on arithmetic items; the spring, on algebra. This research followed the National Longitudinal Study of Mathematical Abilities (NLSMA) pattern of conceptualizing mathematical achievement as multidimensional (Romberg and Wilson, 1968). NLSMA Y-population scales were used extensively. The NLSMA conception of achievement items can best be described as concentrating on two dimensions: Content and Cognitive Behavior (Romberg and Wilson, 1969, 39-42). The Content dimension contains three areas: Number Systems, Geometry, and Algebra. The Cognitive Behavior dimension has four categories: Computation, Comprehension, Application and Analysis.

The selection of tiems from the NLSMA item pools is indicated on Tables 2 and 3. The number of items falling in each cell of the matrix for the pretesting and posttesting is shown. The items are concentrated in Computation and Comprehension at both testings. From fall to spring, the content clearly shifts from Number Systems to Algebra. Few items are in the Applications Category because the NLSMA writing team found them practically impossible to write.

Tables 4 and 5 break down the items according to the NLSMA classification and show means, standard deviations, and reliabilities. Data is from fifty classes from the fall testing and forty-six on the spring testing. For the forty-six classes with data on both testings, only students who were in both testings were used in the computation of means. The four extra classes are retained because they provided data for other parts of the study. The means and

standard deviations are reported using the corresponding Y-scales to have ability for comparing this sample to NLSMA. The final data analysis collapsed posttest scales into Computation, Comprehension, and Analysis.

TABLE 2

DISTRIBUTION OF PRETEST ITEMS IN THE PRETEST PROCESS BY CONTENT MATRIX

	CONTENT		
Process	Number Systems	Geometry	Algebra
Computation	20	0	0
Comprehension	16	0	8
Application	9	0	0
Analysis	8	0	5

TABLE 3

NUMBER OF ITEMS IN EACH CELL OF THE PROCESS BY CONTENT MATRIX FOR POSTTESTS

	CONTENT		
Process	Number Systems	Geometry	Algebra
Computation	0	0	41
Comprehension	8	6	17
Application	0	0	0
Analysis	0	1	11

TABLE 4

MEANS, STANDARD DEVIATIONS, AND RELIABILITIES FOR SCALES IN THE FALL TESTING (n=50 classes)

SCALE	n of items	NLSMA CODE	MEAN	SD	r	NLSMA r
Rationals	20	Y301-306	11.97	1.44	.83	.83 .69 .75
High Cognitive Problems	5	Y012	3.00	.47	.60	.66
Problem Formulation	4	Y110	1.20	.39	.59	.34
Whole Numbers	5	Y307	2.84	.43	.44	.69
Ratl. Numbers	11	Y308	5.28	.70	.51	.63
Numbers - Problems	4	Y309	1.42	.35	.45	.44
Numbers - Logical Analysis	4	Y310	.91	.32	.42	.31
Algebra Number Props	6	Y311	3.48	.45	.43	.63
Algebra Sentences	5	Y312	2.49	.48	.51	.67
Algebra Translation	2	Y313	.81	.22	0	.38
Numbers Combined	24	Y319	10.44	1.33	.73	.82
Algebra Combined	13	Y320	6.77	.91	.67	.80

TABLF 5

MEANS, STANDARD DEVIATIONS, AND RELIABILITIES FOR SCALES IN THE SPRING TESTING (n-46 classes)

SCALE	ITEMS	NLSMA CODE	MEAN	SD	r	NLSMA r
Numbers-2	8	Y501	4.81	.60	.57	.56
Algebraic Expressions-3	20	Y502	10.27	1.65	.85	.82
Algebraic Equations-4	15	Y503	6.54	1.05	.73	.74
Algebraic Inequalities	7	Y504	4.14	.70	.74	.54
Graphs	6	Y505	3.72	.73	.67	.53
Informal Geometry	1	Y506	.46	.20	-	.55
Analysis-3	11	Y507	3.80	.64	.47	.49
Algebraic Sentences-2	6	Y515	3.34	.71	.75	.64
Algebra Translation	4	Y516	1.92	.46	.60	.34
Algebra Number Properties	6	Y517	4.30	.63	.61	.57

Attitudes

NLSMA developed scales on attitudes toward mathematics. Those scales were used for the fall and spring testings. The scales have the following descriptions.

Math Fun vs. Dull - This scale is designed to measure the pleasure or boredom a student experiences with regard to mathematics both in the absolute sense and comparatively with other subjects. (High score - Math is fun)

Math vs. Non-Math - This scale is designed to measure how well a student likes mathematics and considers it important to other subjects. (High score - likes)

Pro-Math Composite - This scale is designed to measure general attitude toward mathematics. It overlaps with Math vs. Non-Math, Math Fun vs. Dull, and Math Easy vs. Hard. (High score - Pro-Math)

Math Easy vs. Hard - This scale is designed to measure the ease or difficulty which a student associates with mathematics. (High score - Math is easy)

Ideal Math Self-Concept - This scale is designed to measure how a child wishes he were in relation to mathematics. (High - better self-image)

Facilitating Anxiety - This scale is designed to measure the degree to which mathematics achievement performance is facilitated by stressful conditions (e.g., examinations) (High - better facilitating anxiety)

Debilitating Anxiety - This scale is designed to measure the degree to which mathematics achievement performance is harmed by stressful conditions (e.g., examinations) (High - lack of debilitating anxiety*)

Actual Math Self-Concept - This scale is designed to measure how a child sees himself in relation to mathematics. (High - Positive)

The development of the scales is described in Romberg and Wilson (1968, pp 151-156).

As was done with the aptitude scales, two reliabilities can be reported: r_1, the internal consistency based on students; r_2, the internal consistency based on class means. These, along with means and standard deviations are on Tables 6 and 7. All means declined over the year.

*This is the reverse of NLSMA scoring.

TABLE 6

MEANS, STANDARD DEVIATIONS, AND RELIABILITIES FOR ATTITUDE SCALES, FALL TESTING (n=50 classes)

SCALE	NLSMA CODE	N of items	MEAN	SD	r_1	r_2	NLSMA r
Math vs. Non-Math		8	20.88	1.17	.66	.74	.68
Math Fun vs. Dull		4	13.60	1.11	.81	.85	.84
Promath Composite		11	33.05	1.56	.63	.76	.68
Math Easy vs. Hard		9	27.57	1.44	.73	.80	.78
Math Ideal Self-Concept		8	26.68	1.44	.76	.59	.76
Facilitating Anxiety		9	24.35	1.26	.61	.74	.67
Debilitating Anxiety		10	33.80	1.88	.81	.88	.85
Actual Math Self-Concept		8	33.08	1.58	.74	.69	.79

TABLE 7

MEANS, STANDARD DEVIATIONS, AND INTERNAL CONSISTENCY RELIABILITIES FOR ATTITUTE SCALES USED IN THE SPRING TESTING (n=46 classes)

SCALE	Items	Means	SD	r
Math vs. Non Math	8	19.75	1.69	.79
Math Fun vs. Dull	4	12.86	1.40	.80
Promath Composite	11	32.18	2.26	.78
Math Easy vs. Hard	9	26.38	1.99	.79
Facilitating Anxiety	9	25.20	1.79	.72
Debilitating Anxiety	10	31.42	1.67	.68
Actual Math Self Concept	8	28.93	1.96	.67

Assignment of Items to Students

One of the problems in a multivariate study of pupil change is measuring that change without forcing the student to spend an excessive amount of time in testing. The two days used at the beginning of the algebra course and two days at the end were not sufficient for every student to take the 149 items on the pretest forms and 176 items on the posttest. With the exception of the STEA and the attitude items on the pretesting, none of the other items were administered to all students within a class. Instead, most of the items were on forms which were randomly assigned to 50% of the students in a class. On the pretest, the assignment of forms was done by the teacher passing out presorted forms to his class. On the posttest, the researcher randomly assigned forms to test packets which were labeled with the students' names. On the posttesting, student answers to the multiple choice items were recorded on mark-sense cards which had been prepunched with their names and project identification codes.

The use of portions of a class for each scale determined that the basic item data for this study would be in the form of class item means. Scales were constructed from the item means. Reliability estimates were based on internal consistency formulas using a class by item design.

MEASURES OF TEACHER BEHAVIOR

Observation Scales Used by Researcher

The researcher and a second observer visited the 47 teachers four times during the year, twice each semester. Two low-inference behavior observation instruments were used during the observation

period: the Wright-Proctor and OScAR 4V. At the end of the observation period, the observer used scales developed from Characteristics of Teachers (Ryans, 1961). During the second semester, a second rating sheet based on the Rosenshine and Furst review (1971) of process-product studies was added.

TCS Scales

Characteristics of Teachers (Ryans, 1960) produced scales which were tested and validated over large samples of elementary and secondary school classrooms. The scales which have been used in several large-scale mathematics studies are based on items formed by antonyms. The observer rates the teacher on a scale from 1 to 7 depending on the work which is more appropriate. For example: PARTIAL 1 2 3 4 5 6 7 FAIR

Four items were added to the list from Characteristics of Teachers in an attempt to pick up special characteristics of algebra classrooms. These were: Practical - Theoretical,

Abstract - Concrete,

Vague - Clear,

Static - Active.

The full list of characteristics is on Table 8. Reliabilities are based on differences between classes with observations not matched within visits. Four observations were available on 43 of the classes; three, on four other classes.

TABLE 8

ITEMS USED FOR RATING CLASS SESSIONS WITH RELIABILITIES OVER 4 VISITS

Item	r
Partial-Fair	.61
Practical-Theoretical	.53
Autocratic-Democratic	.07
Aloof-Responsive	.71
Restricted-Understanding	.70
Harsh-Kindly	.62
Dull Stimulating	.80
Stereotyped-Original	.75
Apathetic-Alert	.82
Unimpressive-Attractive	.71
Evading-Responsible	.65
Erratic-Steady	.73
Excitable-Poised	.68
Uncertain-Confident	.70
Disorganized-Systematic	.79
Inflexible-Adaptable	.62
Pessimistic-Optomistic	.78
Immature-Integrated	.39
Abstract-Concrete	.47
Narrow-Broad	.52
Vague-Clear	.75
Static-Active	.69

Alpha Factor Analysis was used to reduce the mean scores on the scales to four factors with eigenvalues greater than 1. These were rotated to the varimax criterion. The rotated factor loadings were compared with those from the Ryans study (1960, p. 106). The comparisons warranted labeling the factor scores in this study similar to the Ryans on Table 9. Rather than using the Ryans set of items, factor scores were generated for later analyses.

Table 9

IDENTIFICATION OF FACTORS IN THIS STUDY
WITH *CHARACTERISTICS OF TEACHERS* SCALES

	This Study		Characteristics of Teachers
TCSY	Responsible, Steady, Poised, Systematic vs. Evading, Erratic, Excitable, Disorganized	Y_o	Responsible, systematic vs. Evading, Disorganized
TCSZ	Stimulating, Original, Alert, Broad vs. Dull, Stereotyped, Apathetic, Narrow	Z_o	Stimulating, Original vs. Dull, Stereotyped
TCSX	Democratic, Kindly vs. Autocratic, Harsh	X_o	Responsible, Understanding, Kindly, Democratic, Optimistic vs. Aloof, Restricted, Harsh, Autocratic, Pessimistic
TCSC	Concrete, Practical vs. Abstract, Theoretical		(No comparative scale)

Process Rating Sheet

A second rating scale was introduced for the last two observations. Following the Rosenshine-Furst review of process-product studies (1971), it has ten items to be rated on a 1 (low) to 5 (high) scale. No formal glossary such as that available for the TCS scales were used. It should be noted that one of the variables cited by Rosenshine and Furst does not appear on this sheet. That is "Student Opportunity to Learn Criterion Material." This variable was not an appropriate one for rating a class session.

The ratings on five of the items were high for most teachers despite the efforts of the observers to aim for a distribution of ratings centering on three. The average of only three of the items were close to three.

The correlations between ratings on the third and fourth visits for the 43 classes on which full observations were completed are on Table 10. "Difficulty of Lesson" was notably unstable across the two visits. The other nine were adequately correlated.

TABLE 10

CORRELATIONS BETWEEN ITEM SCORES ON THE PROCESS RATING SHEET ON CLASS VISITS 3 and 4 for 43 CLASSES

	Item	r
PR1	Clarity	.382*
PR2	Variability	.375*
PR3	Enthusiasm	.636**
PR4	Business-like	.533**
PR5	Uses Student Ideas	.398**
PR6	Criticism	.565**
PR7	Structures Lesson	.347*
PR8	Higher Cognitive Questions	.595**
PR9	Probing Questions	.332*
PR10	Difficulty of Lesson	-.147

* P $<$ .01

**P $<$ .05

<u>Observation Scales Used by Students</u>

Classroom Activities Questionnaire

The Classroom Activities Questionnaire (CAQ) attempts to provide a low-inference rating sheet which students may use to rate their teacher. It is based on the Bloom taxonomy of Educational Objectives (Bloom, 1956). It has been used with mathematics classrooms for gifted students (Steele, et al, 1970) and was included in this study because it related to the Wright-Proctor observation scale.

The structure of the CAQ is indicated on Table 11. Further information on its development can be found in Steele, et al (1971). The CAQ was administered to 50% of the students in each class at the end of the first semester. Items were scored so that high scores imply more of the construct implied in the scale title, with the exceptions of Test/Grade Stress and Lecture.

TABLE 11

Scales from Class Activities Questionnaire

Identifier	Description
CAQM	Memory -- Recall and Recognition of information
CAQT	Translation -- Paraphrasing or expressing information in different symbolic form
CAQI	Interpretation -- Recognition of relationships
CAQAP	Application -- Selection of appropriate methods and performance of operations required by problem situation
CAQAN	Analysis -- Recognition of structure of material, including conditions which affect the way it fits together
CAQSY	Synthesis -- Generation of new ideas and solutions
CAQEV	Evaluation -- Development and application of a set of standards for judging worth
CAQDS	Discussion -- Student opportunity for and involvement in discussion
CAQTS	Test/Grade Stress -- High pressure to produce teacher selected answers (High score: low stress)
CAQL	Lecture -- Teacher role as information giver with students in passive, listening role (High score: less time on lecture)
CAQLO	Low Cognitive Composite -- Memory, Translation, Interpretation
CAQHI	High Cognitive Composite -- Application, Analysis, Synthesis, Evaluation
CAQCF	Classroom Focus -- Discussion, Test/Grade Stress, Lecture
CAQCL	Classroom Climate -- Enthusiasm, Independence, Divergence, Humor, Teacher Talk, Homework

From: Steele, et al (1971, p.451)

Classroom Process Questionnaire

The constructs synthesized by Rosenshine and Furst (1971) can be measured by students. Rosenshine provided the researcher with item sets he and his associates had been developing to produce class measures on ten areas of behaviors. These were adapted for algebra classes. A twenty-five item scale was administered to 50% of the students in each class as part of the spring testing. The scales and sample items are on Table 12.

TABLE 12

CLASSROOM PROCESS QUESTIONNAIRE SAMPLE ITEMS

Identifier	Description and Example
RCLAR	Clarity (4 items; r=.80) "My teacher makes his points clear and easy to understand"
RQUEST	Questioning (1 item) "My teacher asks questions in such a way that you really have to think in order to answer them."
RVART	Variability (6 items; r=.63) "My teacher uses many different teaching methods."
RENTHUT	Enthusiasm (4 items; r=.74) "My teacher has high interest in teaching Mathematics."
RDIFFT	Difficulty (3 items; r=.51) "My teacher spends too much time on easy problems."
RCRITT	Criticism (1 item) "My teacher spends too much time criticizing or finding fault with the students in this class."
RUSET	Use of Ideas (2 items; r=.87) "This teacher respects the ideas of his students."
RSTRUCT	Structuring (1 item) "This teacher gives a short summary at the end of the lesson."
ROPPT	Opportunity to Learn (1 item) "This teacher really doesn't give students many opportunities to learn the things they should be learning in Algebra."
RTASKT	Task Orientation (2 items; r=.31) "This teacher really makes you get down to work in class."

SAMPLE

The original pool of schools used for the sample were located within driving distance of Northwestern University. The researcher contacted both city and suburban schools. Districts containing 25 high schools in Chicago and suburban areas were contacted in the Spring of 1971. Three districts declined participation. In the remaining districts, decisions were left to the schools. Four of the schools declined to participate, and four schools were not contacted since unusual scheduling of students, newness of school, or prolonged teacher strikes would have interfered with the progress of the research.

Forty-seven teachers in thirteen schools offered one algebra class each for the project. Four of these teachers also provided a second classroom as well for extra testing. (*) "Regular" or "average" algebra classes had been requested for the study, but entrance requirements for the classes in the sample varied from school to school.

The sample of schools in this study served students from above-average suburban communities. On the basis of the 1971 ranking of Chicago suburbs by the Chicago Regional Hospital Study, twenty of the twenty-six communities served by the thirteen high schools are in the top quartile in economic standing.

Class times of the fifty-one classes tested ranged from 40 minutes to 57 minutes per day. Twenty-five percent of the classes met for 40-44 minutes each day, about one-third met for 45-49 minutes, and the remainder, for 50 or more minutes per day.

(*) One class was dropped by the school at the end of October due to insufficient enrollment.

Classes in the study started as early as 7:50 A.M. and as late as 2:40 P.M. Most of the classes started after 12:00 noon. Several schools were still on split shifts with freshmen coming to school later, and several schools had early release programs which forced upper-level courses to be early in the day.

Although the United States has no national curriculum for algebra, the most popular textbooks in algebra cover substantially the same content. Five different textbooks are used in the fifty-one classrooms. Two of these, Houghton-Mifflin's Modern School Mathematics Algebra and Modern Algebra, were used in 38 of the classes. One other text was used in more than one school, and the two remaining texts were used in one school each.

Neither variables of textbook nor time spent in class per week had any relation to the pupil achievement and attitude measures used in this study.

Teacher Characteristics

Since most of the teachers in this study were volunteers, the researcher felt it important to compare the sample with data available on ninth grade math teachers. Two sources were available. The National Longitudinal Study of Mathematical Abilities, NLSMA, had studied a carefully selected, but large sample of schools in the United States during the 60's. Questions they had asked ninth grade mathematics teachers were used in this study to see how this sample of teachers compared to a more representative national sample (Wilson, et al, #9, 1968). In addition, Bell (1969) had completed a study using Chicago area high school math teachers two years before this study. His research had involved far more teachers and relied on less of a commitment from the teachers. Hence, his

sample is quite representative of math teachers in the Chicago area. He used some of the same questions from NLSMA.

Three-quarters of the teachers in this sample were male. This is typical of both the NLSMA statistics and Bell's suburban data. The distribution of years of experience was typical of both the NLSMA sample and Bell's: 40% were in the 1-6 year range, 28% in the 7-12, and the rest in 13 or more years. 65% of the teachers in this sample had a master's degree or higher. This compares to Bell's suburban data, but not to the figure from NLSMA of 48%. The teachers in this sample tended to belong to more professional organizations devoted to mathematics education than the NLSMA teachers did. On a checklist of five ways of preparing for mathematics teaching, the number of items checked by the teachers in this sample was slightly more than that checked by teachers in the NLSMA sample. Almost all of the teachers had taught algebra before.

Teacher Opinions About Teaching

Teacher attitudes were assessed with the Teacher Opinion Inventory (TOI) of NLSMA (Wilson, et al, #9, 1968, pp. 67-73). Data on the scales in this inventory was compared with the much larger NLSMA grade nine sample. Before presenting the results, it should be pointed out that considerable anxiety was created by the items on the questionnaire. Some teachers refused to complete it; some filled it out by putting on extensive comments. Usable results on all scales were available from only 41 of the 47 teachers.

A t-test for differences of the sample means in this study against the means derived from the NLSMA ninth grade data showed that there were no differences between the scores on this sample of

teachers on the scales.

"Theoretical Orientation"

"Concern for Students"

"Involvement in Teaching"

"Like (math) vs. dislike"

"Creative vs. Rote Orientation to Mathematics"

"Need for Approval"

A difference did show up on "Non-authoritarian Orientation" with the sample teachers showing more democratic, non-authoritarian views of mathematics teaching than the NLSMA grade nine sample.

Attrition

In a project spanning a year of school, attrition is a critical problem. It is even more of a problem in a course such as grade nine algebra, because schools differ in their approach to students who do not have success in algebra. Most schools in this study had a two-year algebra sequence to which low-achieving algebra students were dropped. One school had different levels of one-year algebra. Another school had a policy of pulling out all students who were failing at the end of the first quarter and assigning them to a section which would start the course all over. An attempt was made at the end of the first semester to track down students who were no longer in the sections being studied, but the task was not successful. The most consistent method of analyzing the data was to use only students who were registered in the class both in October, 1971, and in May, 1972, for the computation of class mean scores. About 25% of the students in the fall testing were not in the spring testing.

Fifty classes completed the fall testing. Forty-six completed the spring testing. Four observations were completed on forty-three

of the classes. Where only student data is compared, the forty-six classes will be used. Where observation data is reported, the sample will be the forty-three classes with complete observations.

ANALYSIS OF DATA

The first step in the analysis was the computation of class mean scores on all items administered to students. Scales were constructed from these means. The posttest attitude and achievement scores were regressed on all pretest scales. Many process-product studies which have had pre- and post-measures have regressed posttests only on corresponding pretests. This may be an incomplete correction ~~in mathematics. As an example, consider the attitude scale,~~ "Facilitating Anxiety." The attitude measured by this scale may be more a function of ability than a function of the pretest score on the same measure. By putting all pretest measures into a regression program and selecting the ones which significantly predict posttest scores, more variability from initial differences could be removed.

On the seven attitude measures, one ("Math - Easy vs. Hard") was regressed against its pre-measure only. All others were regressed against at least two premeasures. "Pro-Math Composite," for example, was significantly predicted by fall measures "Math - Fun vs. Dull" and "Symbol Manipulation" from STEA.

The posttest achievement measures regressed against arithmetic scales and STEA subscales.

After the regression sets were determined for each criterion variable, the residuals were computed for each class. These residuals were then correlated against the teacher behavior measures. One-tailed significance tests were selected because the teacher behavior measures had been scaled so that higher scores on each behavior measure should relate positively to attitude and achievement measures.

Hence, the alternates to the null hypotheses on correlations were one-directional. Proportions of variance accounted for (r^2) were also computed. These were tested with an F-ratio, which, in effect, is performing a two-tailed significance test.

RESULTS

ACHIEVEMENT MEASURES

Correlations between achievement residuals and teacher behavior measures are on Table 13. The computation scale had residuals related to three measures distinguishing the task-oriented teacher. The classes who rated their teachers as "making them get down to work" and those classes who had teachers who were rated by the observer higher on "businesslike" and "responsible, steady, poised, systematic" behavior tended to have higher residual scores on computation. This result indicates that systematic teacher behavior has a positive effect on algebraic computation. On the other hand, it should be noted that the cognitive scales of the CAQ questionnaire did not relate to the Computation residual. Task orientation is different from concentration on lower cognitive skills in this regard. It is striking that pupils rated the asking of "thinking" questions in such a way that teacher scores connected with Computation.

The Comprehension residual correlated with clarity as measured by observer and pupils. Teachers rated as clearer had higher residual achievement. Task Orientation, as rated by pupils, correlated with residuals.

The highest cognitive level, Analysis, had residuals which correlated negatively with two CAQ scales, and positively with the observer scale "Probing," and pupil rating scale, "Enthusiasm." The negative correlations are due to lecture: the less time spent on lecture, the lower the analysis residual. These results are not

contradictory. The teachers who are rated by the students as enthusiastic and by the observer as asking probing questions are probably spending most of the period talking. The title of the CAQ variable may be deceiving in this regard. Teachers who asked probing questions were not lecturing but were accounting for a high proportion of the talking.

None of the CAQ scales measuring levels of cognitive emphasis correlated with the Analysis residual. Results for the Analysis scale are therefore not as clear-cut as the Computation and Comprehension Scales.

TABLE 13

SIGNIFICANT CORRELATIONS BETWEEN RESIDUAL CHANGES ON CLASS ACHIEVEMENT MEASURES AND TEACHER BEHAVIOR MEASURES WITH PROPORTION OF VARIANCE OF RESIDUALS ACCOUNTED FOR (R^2)

Class Measure (Residual)	r	P<*	r^2	P< **	Teacher Behavior Measure: Identifier	Description	Source
Computation (RESCOMPU)	.31	.018	.10	.036	RTASKT	Task Orientation	Pupils
	.28	.030	.08	.061	RQUEST	Questioning	Pupils
	.28	.032	.08	.065	PR4	Businesslike	Observer
	.26	.047	.07	.095	TCSY	Responsible-Steady	Observer
Comprehension (RESCOMPRE)	.28	.034	.08	.068	PR1	Clarity	Observer
	.28	.030	.08	.061	RTASKT	Task Orientation	Pupils
	.26	.039	.07	.077	RCLART	Clarity	Pupils
Analysis (RESANALY)	-.42	.003	.18	.005	CAQL	Lecture	Pupils
	-.30	.027	.09	.055	CAQCF	Classroom Focus	Pupils
	.27	.037	.08	.074	PR9	Probing	Observer
	.26	.043	.06	.086	RENTHT	Enthusiasm	Pupils

N for correlations with Teacher Behavior Measures whose identifier starts with "R" is 46.
N for other Teacher Behavior Measures is 43.

*Significance based on one-tailed test.
**Significance based on proportion of variance accounted for by predictor.

ATTITUDE MEASURES

The results of correlating teacher behavior measures with residuals on attitude measures provided many significant relationships. The significant correlations are on Table 14.

Math - Fun vs. Dull

Residuals on this scale were positively correlated with pupil and observer measures of

Clarity (PR 1 and RCLART),

Enthusiasm (RENTHUT and TCSZ), and

Businesslike behavior (PR4 and RTASKT).

In addition, "Opportunity to Learn," as measured by the pupils, correlated positively with this attitude residual. If a teacher was rated as providing students the "Opportunity ~~to~~ Learn" Algebra, students had higher residuals on "Math Fun vs. Dull." A striking contradiction occurs with the observer rating on "Higher Cognitive Questions" relating positively to these attitude residuals, but the pupil ratings of teacher emphasis on "Analysis" correlating negatively. This contradiction is consistent with the result on the next variable.

Math vs. Non-Math

The residuals on this scale relate to teacher Clarity (PR1 and RCLART) and teacher (enthusiasm - TCSZ and RENTHUS) as measured by both observer and pupils. In addition, teachers related as "Businesslike" by the observer had higher class residuals on Math vs. Non-Math. Teachers rated lower by their classes on analysis, but higher classes with higher residuals.

Pro-Math Composite

Since this scale uses items from the previous two and the following, many of the results are redundant and will not be discussed.

TABLE 14

SIGNIFICANT CORRELATIONS BETWEEN RESIDUAL CHANGES ON CLASS ACHIEVEMENT MEASURES AND TEACHER BEHAVIOR MEASURES WITH PROPORTION OF VARIANCE OF RESIDUALS ACCOUNTED FOR (R^2)

Class Measure (Residual)	r	P<*	r^2	P<**	Teacher Behavior Measure: Identifier	Description	Source
Math Fun vs. Dull (RESFUN)	.36	.009	.13	.017	PR1	Clarity	Observer
	.34	.014	.11	.027	PR4	Businesslike	Observer
	.31	.018	.10	.037	RENTHT	Enthusiasm	Pupils
	.30	.026	.09	.053	TCSZ	Exciting-Stimulating	Observer
	.28	.029	.08	.057	ROPPT	Opportunity to Learn	Pupils
	.28	.030	.08	.061	RCLART	Clarity	Pupils
	.28	.033	.08	.066	PR8	High Cognitive Quest.	Observer
	.26	.039	.07	.079	RTASKT	Task Orientation	Pupils
	-.25	.050	.06	.100	CAQAN	Analysis	Pupils
Math vs. Nonmath (RESMATH)	-.37	.008	.13	.024	CAQAN	Analysis	Pupils
	.35	.008	.12	.016	RENTHT	Enthusiasm	Pupils
	.35	.011	.12	.021	PR4	Businesslike	Observer
	.31	.021	.10	.041	TCSZ	Exciting-Stimulating	Observer
	.30	.023	.09	.045	RCLART	Clarity	Pupils
	.26	.048	.07	.095	PR8	High Cognitive Quest.	Observer
	.25	.050	.06	.099	PR1	Clarity	Observer
Pro-Math Composite (RESPRO)	.38	.007	.14	.013	PR1	Clarity	Observer
	.37	.006	.13	.012	RCLART	Clarity	Pupils
	.32	.016	.10	.032	RENTHT	Enthusiasm	Pupils
	.32	.017	.10	.034	PR4	Businesslike	Observer
	.31	.019	.09	.039	ROPPT	Opportunity to Learn	Pupils
	.31	.022	.10	.044	CAQCL	Classroom Climate	Pupils
	.30	.026	.09	.052	CAQAP	Applications	Pupils
	.29	.024	.09	.047	RTASKT	Task Orientation	Pupils
	.29	.031	.08	.062	TCSZ	Exciting-Stimulating	Observer
	-.27	.042	.07	.084	CAQM	Memory	Pupils
	.26	.047	.07	.093	PR8	High Cognitive Quest.	Observer
	.26	.047	.07	.094	PR7	Structures Lesson	Observer

(Continued)

TABLE 14 (Continued)

Class Measure (Residuals)	r	P<	r^2	P<	Identifier	Description	Source
Math Easy vs.	-.45	.001	.21	.002	CAQAN	Analysis	Pupils
Hard	.27	.037	.08	.075	TCSZ	Exciting-Stimulating	Observer
(RESEASY)	.27	.040	.07	.081	PR1	Clarity	Observer
Facilitating	.31	.018	.10	.036	RCLART	Clarity	Pupils
Anxiety	.31	.018	.10	.037	RTASKT	Task Orientation	Pupils
(RESFANX)	-.27	.038	.07	.076	CAQL	Lecture	Pupils
Debilitating	.27	.038	.07	.076	TCSZ	Exciting-Stimulating	Observer
Anxiety	.25	.050	.06	.100	PR6	Criticism	Observer
(RESDEBX)							
Actual Math	.46	.001	.21	.001	RTASKT	Task Orientation	Pupils
Self-Concept	.38	.005	.14	.009	RCLART	Clarity	Pupils
(RESACT)	.35	.009	.12	.018	RENTHT	Enthusiasm	Pupils
	.32	.019	.10	.037	TCSZ	Exciting-Stimulating	Observer
	-.30	.024	.09	.048	CAQLO	Low Cognitive Composite	Pupils
	.30	.024	.09	.049	PR1	Clarity	Observer
	.27	.033	.07	.067	ROPPT	Opportunity to Learn	Pupils

N for correlations with Teacher Behavior Measures whose identifier starts with "R" is 46.
N for other Teacher Behavior Measures is 43.

*Significance based on one-tailed test.
**Significance based on proportion of variance accounted for by predictor.

<u>Math Easy vs. Hard</u>

Observer ratings of the teacher on "Clarity" and "Exciting-Stimulating" correlated positively with residuals. A striking negative result is the correlation of the residuals with pupils' rating of their teacher's emphasis on analysis.

<u>Facilitating Anxiety</u>

All variables which correlated with residuals on facilitating anxiety were from pupils. Teachers rated higher on clarity and task-orientation had higher residuals. Teachers who spent more time talking had classes with higher facilitating anxiety.

<u>Debilitating Anxiety</u>

Two observer measures correlated with residuals. Teachers rated as more exciting and using more criticism of pupil statements had higher residuals on debilitating anxiety. It should be recalled that higher scores on this scale indicate <u>absence</u> of debilitating anxiety.

<u>Actual Math Self-Concept</u>

Clarity and teacher enthusiasm as measured by both pupils and observer related positively to residuals on actual math self-concept. Further, pupils' rating of teachers on "Task Orientation" and providing an "Opportunity to Learn Algebra" were positively related to residuals on this attitude scale. Finally, classes which rated their teacher as giving more emphasis to lower cognitive skills had lower residuals on this scale.

SUMMARY

DISCUSSION OF FINDINGS

Factors synthesized by Rosenshine and Furst (1971) as teacher behaviors relating to pupil achievement showed up in this study as important for attitudes towards mathematics. The most consistent results centered on teacher behaviors of clarity, enthusiasm, and task orientation (businesslike) behaviors. Whether ratings were completed by the classroom observer or by the pupils, teachers who were rated as clearer, as more enthusiastic, and as more businesslike had classes with higher residual attitudes.

The results for achievement differences were not as productive. Nevertheless, teachers rated as more businesslike had classes with higher residuals on computation, and teachers rated as clearer had classes with higher residuals on comprehension.

A surprising result occurred in the classification of teacher behavior on a cognitive dimension. Teachers whose pupils rated them as emphasizing analysis activities had no better achievement than other teachers but did have classes with lower residual attitudes towards mathematics on several scales. It appears that, if pupils perceive their teacher as spending more time in analysis questions and activities, they will view mathematics as being harder, duller, and less attractive than non-math courses.

A second unexpected result centered about the pupils' perception of the amount of time their teacher spent talking. Teachers who were rated as talking more had classes which had higher residuals on the analysis scale. It is possible that these teachers who spent more time talking were actually having the students perform the analysis of problems. This possibility is supported by the observer's ratings

of the teachers on the "Probing" measure relating positively with the residuals on analysis. In fact, it was a notable characteristic of the algebra classrooms in this study that, even though the teachers accounted for the bulk of classroom talk, they rarely talked for more than a minute without asking for a response from the students.

SIGNIFICANCE OF THE STUDY

This study used high-inference teacher behaviors which were synthesized from process-product studies. It was unusual in that different sources were used for rating teacher behaviors--an outside observer and the residents of the classroom, the pupils. Outcome measures were multidimensional to permit a variety of teacher influence to emerge.

The narrowing of this study to suburban schools and one subject, ninth-grade algebra, did not severely impair the generalizability of the results. On the other hand, this restriction makes the results more valuable to mathematics education. Rating sheets for student teachers in mathematics should emphasize some of the behavior constellations found important in this study. High schools should promote the teacher behaviors of clarity, businesslike behavior, and enthusiasm in their freshmen algebra classes. These behaviors will lead to a modest improvement in class attitudes towards mathematics. An improvement in attitudes, however modest, may substantially increase the number of students electing mathematics courses beyond algebra.

FURTHER RESEARCH

The data collected in this study included low-inference teacher behavior measures. The next question to be investigated is how low-inference teacher behaviors relate to the high-inference behaviors cited in this paper as important for pupil achievement and attitude.

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